CLAIMS

We claim:

Sub C1 ~~1. A method for making a multi-layer electronic structure, the method~~ comprising:

providing a layer of dielectric material having a top surface and a bottom surface;

providing a layer of electrically conducting material on one of the top surface and the bottom surface of the dielectric layer;

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forming at least one passage through the dielectric layer to expose the layer of electrically conducting material;

depositing electrically conducting material in at least one of the at least one passage through the dielectric layer;

removing portions of the layer of electrically conducting material to define a pattern of circuitry;

stacking a plurality of structures comprising the layer of dielectric material and layer of electrically conducting material;

aligning the plurality of structures;

joining the plurality of structures such that the electrically conducting material in at least one of the at least one passage through the dielectric material electrically connects ~~the conductive pattern disposed on the dielectric layer with another conductive pattern on~~

~~and adjacent structure of the stacked plurality of structures; and~~

~~filling spaces between the structures with electrically insulating material.~~

2. The method according to claim 1, wherein the dielectric material is selected from the group consisting of free standing organic film, fiber reinforced resin sheet, particulate filled fluoropolymer sheet, or resin filled expanded fluoropolymer sheet.

3. The method according to claim 2, wherein the free standing organic film is polyimide film.

4. The method according to claim 2, wherein the free standing organic film is a liquid crystal polymer film.

5. The method according to claim 2, wherein the fiber reinforced resin sheet includes at least one of glass, aramid, and liquid crystal polymer fibers and the fibers are woven or non-woven.

6. The method according to claim 1, wherein a layer of electrically conducting material is provided on both the top surface and the bottom surface of the layer of dielectric material.

7. The method according to claim 1, wherein the layer of electrically conducting material is patternable is solderable or can have a solderable surface layer applied.

8. The method according to claim 1, wherein the layer of electrically conducting material comprises at least one metal.

9. The method according to claim 1, wherein the layer of electrically conducting material comprises copper.

10. The method according to claim 1, wherein the layer of electrically conducting material is provided by a method selected from the group consisting of lamination, physical vapor deposition, plating, and chemical vapor deposition.

11. The method according to claim 10, wherein the physical vapor deposition comprises vacuum evaporation or sputtering.

12. The method according to claim 10, wherein the plating comprises electroplating or electroless plating.

13. The method according to claim 1, wherein the layer of dielectric material is provided by applying dielectric material to the layer of electrically conducting material.

14. The method according to claim 13, wherein the electrically conducting material comprises copper.

15. The method according to claim 13, wherein the dielectric material is applied to an electrically conductive foil by a method selected from the group consisting of screening, slot coating, curtain coating, doctor blading, roll coating, rod coating, dip coating, and spraying.

16. The method according to claim 1, further comprising:

applying a layer of a protective material on the layer of electrically conducting material.

17. The method according to claim 1, wherein the at least one passage through the dielectric layer is formed by laser drilling or plasma etching.

18. The method according to claim 1, wherein the electrically conducting material deposited in at least one of the at least one passage through the dielectric layer does not extend beyond an opening of the at least one passage.

19. The method according to claim 1, wherein the electrically conducting material

deposited in at least one of the at least one passage through the dielectric layer does at least partially extends beyond an opening of the at least one passage.

20. The method according to claim 1, wherein the electrically conducting material is deposited in at least one of the at least one passage through the dielectric layer by plating or introducing electrically conducting paste into the at least one passage.

21. The method according to claim 21, wherein the electrically conducting material is deposited in at least one of the at least one passage through the dielectric layer by plating and the plating is electroplating or electroless plating.

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22. The method according to claim 1, wherein the electrically conducting material is deposited in at least one of the at least one passage through the dielectric layer by introducing electrically conducting paste into the at least one passage, wherein the introduction of the electrically conducting paste comprises forcing the conducting paste into the at least one passage and curing the conducting paste.

23. The method according to claim 22, wherein forcing the conducting paste into the at least one passage comprises squeegeeing the conducting paste.

24. The method according to claim 1, further comprising:
providing a cap on the electrically conducting material in the at least one passage.

25. The method according to claim 24, wherein the cap comprises tin.

26. The method according to claim 24, wherein the cap comprises a tin-containing alloy.

27. The method according to claim 24, wherein the cap has a thickness of about 0.0001 inch to about 0.0004 inch.

28. The method according to claim 24, wherein the cap is provided by plating an electrically conducting material on the electrically conducting material in the at least one passage.

29. The method according to claim 28, wherein the plating is electroplating or electroless plating.

30. The method according to claim 28, wherein the plating is maskless and self-aligning.

31. The method according to claim 1, further comprising:

applying a protecting coating over the layer of electrically conducting material on the dielectric layer, wherein the protecting layer is removed prior to removing portions of the layer of electrically conducting material to define a pattern of circuitry.

32. The method according to claim 1, wherein removing portions of the layer of electrically conducting material to define a pattern of circuitry comprises depositing a layer of photoresist on the layer of electrically conducting material, exposing the photoresist, developing the photoresist to form a mask for selectively removing portions of the layer of electrically conducting material, and removing remaining portions of the photoresist.

33. The method according to claim 1, further comprising:

treating the layer of dielectric material and the pattern of circuitry with an immersion tin plating solution.

34. The method according to claim 1, further comprising:

treating the layer of dielectric material and the pattern of circuitry in a fluorine-containing plasma.

35. The method according to claim 1, wherein the structures are aligned with at least one of aligning pins and aligning marks.

36. The method according to claim 1, wherein the structures are stacked one-by-one and each time another structure is added to the stack it is soldered to a structure in the stack.

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37. The method according to claim 1, wherein joining the structures comprises heating the structures to a temperature above a melting point of at least one of the constituent materials of, or the cap deposited on, the electrically conducting material deposited in the at least one passage in the dielectric layer.

38. The method according to claim 37, wherein joining the structures further comprises applying pressure to the stack from above and below.

39. The method according to claim 37, wherein the joining is carried out in an atmosphere that is inert under the conditions that the joining is carried out under.

40. The method according to claim 39, wherein the joining is carried out in a nitrogen atmosphere.

41. The method according to claim 37, wherein the joining is carried out under a vacuum.

42. The method according to claim 1, wherein the spaces between the structures are filled with a low viscosity, thermosetting resin.

43. The method according to claim 42, wherein filling the spaces comprises arranging a gas impermeable flexible covering about the plurality of structures, sealing a periphery of the plurality of structures in the vicinity a top and a bottom surface of the plurality of structures, and introducing the resin into the covering.

44. The method according to claim 43, wherein after introduction the resin is cured.

45. The method according to claim 16, wherein the protective material is photoresist.

46. A multi-layer electronic structure, comprising:

Sub B4 at least two substructures joined together, each substructure comprising a layer of dielectric material having a top surface and a bottom surface, a pattern of circuitry on one of the top surface and the bottom surface of the layer of dielectric material, and at least

one passage through the dielectric layer in connection with the circuitry, the at least one passage being filled with electrically conducting material, the at least two substructures being stacked on each other such that one of the electrically conducting material filling the at least one passage and the circuitry pattern on one substructure contacts and is electrically conductively joined to one of the electrically conducting material filling the at least one passage and the circuitry pattern on another substructure; and

electrically insulating material substantially filling a space between facing substructures except between a joined filled passage and a circuitry pattern.

47. The structure according to claim 46, wherein the dielectric material is selected from the group consisting of free standing organic film, fiber reinforced resin sheet, or particulate filled fluoropolymer sheet, or resin filled expanded fluoropolymer sheet.

48. The structure according to claim 47, wherein the free standing organic film is polyimide film.

49. The structure according to claim 47, wherein the free standing organic film is a liquid crystal polymer film.

50. The structure according to claim 47, wherein the fiber reinforced resin sheet includes at least one of glass aramid, and liquid crystal polymer fibers and the fibers are

woven or non-woven.

51. The structure according to claim 46, wherein the layer of electrically conducting material comprises at least one metal.

52. The structure according to claim 46, wherein the layer of electrically conducting material comprises copper.

53. The structure according to claim 46, wherein the electrically conducting material deposited in the at least one passage through the dielectric layer comprises at least one metal, alloy, or electrically conducting paste.

54. The structure according to claim 46, further comprising:

a cap on the electrically conducting material in the at least one passage.

55. The structure according to claim 54, wherein the cap comprises tin.

56. The structure according to claim 54, wherein the cap comprises a tin-containing alloy.

57. The structure according to claim 54, wherein the cap has a thickness of about 0.0001 inch to about 0.0004 inch.

58. The structure according to claim 46, further comprising:

a layer of tin oxide on the pattern of circuitry.

59. The structure according to claim 46, wherein the layer of dielectric material and the pattern of circuitry have been treated in a fluorine-containing plasma prior to stacking and joining the substructures.

60. The structure according to claim 46, further comprising:

an aligning structure for aligning the substructures.

61. The structure according to claim 60, wherein the aligning structure comprises at least one aligning passage for receiving and aligning pin.

62. The structure according to claim 60, wherein the aligning structure comprises at least one aligning mark on each substructure.

63. The structure according to claim 46, wherein the substructures are soldered together.

64. The structure according to claim 46, wherein the spaces between the structures are filled with a low viscosity, thermosetting resin.

65. The structure according to claim 64, wherein the resin is cured.

66. An electronic package, comprising:

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a multi-layer structure comprising at least two prefabricated substructures joined together, each substructure comprising a layer of dielectric material having a top surface and a bottom surface, a pattern of circuitry on one of the top surface and the bottom surface of the layer of dielectric material, and at least one passage through the dielectric layer in connection with the circuitry, the at least one passage being filled with electrically conducting material, the at least two substructures being stacked on each other such that one of the electrically conducing material filling the at least one passage and the circuitry pattern on one substructure contacts and is electrically conductively joined to one of the electrically conducting material filling the at least one passage and the circuitry pattern on another substructure; and electrically insulating material between facing substructures except between a joined filled passage and a circuitry pattern; and

a semiconductor chip attached to the multi-layer structure.

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~~67. An electronic package, comprising:~~

a printed wiring board comprising at least two prefabricated substructures joined together, each substructure comprising a layer of dielectric material having a top surface and a bottom surface, a pattern of circuitry on one of the top surface and the bottom surface of the layer of dielectric material, and at least one passage through the dielectric layer in connection with the circuitry, the at least one passage being filled with electrically conducting material, the at least two substructures being stacked on each other such that one of the electrically conducting material filling the at least one passage and the circuitry pattern on one substructure contacts and is electrically conductively joined to one of the electrically conducting material filling the at lease one passage and the circuitry pattern on another substructure; and electrically insulating material between facing substructures except between a joined filled passage and a circuitry pattern; and

~~a plurality of electronic components attached to the printed wiring board.~~

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68. A method for making a multi-layer electronic interconnect structure, the method comprising:

providing a layer of dielectric material bonded to a layer of electrically conductive material, the layer of dielectric material having substantially uniform thickness;

forming at least one passage through the layer of dielectric material to expose a portion of the layer of electrically conductive material;

depositing electrically conducting material in at least one of the at least one

passage through the layer of dielectric material, such that the electrically conducting material in the at least one passage is in electrical contact with the layer of electrically conducting material bonded to the layer of dielectric material and extends beyond a surface of the layer of dielectric material;

removing portions of the layer of electrically conducting material to define a pattern of circuit conductors, such that at least one of the circuit conductors remains electrically connected to the electrically conductive material deposited in that at least one of the at least one passage through the layer of dielectric material;

stacking and aligning a plurality of structures comprising the layer of dielectric material with circuit conductors disposed thereon and conductively filled passages therethrough such that one of the following conditions exists:

a) at least one conductively filled passage in a structure contacts at least one circuit conductor on the conductive layer of an adjacent structure,

b) at least one circuit conductor on the conductive layer of a structure contacts at least one conductively filled passage in an adjacent structure, or

c) at least one conductively filled passage in a structure contacts at least one conductively fined passage in an adjacent structure;

electrically and mechanically joining the electrically conductive material filled one of the at least one passage that is aligned with an electrically conductive feature on an adjacent structure to the adjacent structure conductive features; and

filling spaces between the adjacent structures with an electrically insulating material.

69. The method according to claim 68, wherein the electrically insulating material used to fill spaces between the adjacent structures comprises a liquid which is transformed into a solid subsequent to filling the spaces.

70. The method according to claim 69, wherein the transformable insulating material is an organic resin.

71. The method according to claim 70, wherein the organic resin includes at least one member selected from the group consisting of epoxy, acrylic, cyanate ester, urethane, polyester, bismaleimide triazine, silicone, and mixtures or copolymers thereof.

72. The method according to claim 70, wherein the transformable electrically insulating material comprises at least one inorganic particulate filler in an amount up to about 60 percent by volume.

73. The method according to claim 70, wherein the transformable electrically insulating material is converted to a solid by at least one means selected from the group consisting of chemical polymerization and cross linking reactions.

74. The method according to claim 68, wherein filling spaces between adjacent structures comprises introducing a liquid electrically insulating material into the spaces and allowing capillary forces to transport the liquid from a point of introduction throughout the spaces.

75. The method according to claim 74, wherein the liquid electrically insulating material is introduced at least one point around peripheries of the layers of dielectric material.

76. The method according to claim 74, wherein the liquid electrically insulating material is introduced at a pressure greater than atmospheric pressure in order to provide a larger driving force for material transport than provided by capillary forces alone.

77. The method according to claim 74, wherein a vacuum is created and maintained in spaces between the adjacent structures during a time when the liquid electrically insulating material is being introduced.

78. The method according to claim 77, further comprising:

arranging a gas impermeable flexible covering about the plurality of structures;

sealing the flexible covering to the plurality of structures about top and bottom

peripheries of the structures;

evacuating the atmosphere from within the flexible covering;

introducing a liquid electrically insulating material into the evacuated covering in the vicinity of at least one edge of the plurality of structures;

allowing the liquid electrically insulating material to fill the spaces between structures;

transforming the liquid electrically insulating material into a solid; and

removing the gas impermeable covering.